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6. AUTHOR(S)
Ken Nakayama

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
President + Fellows of Harvard College
Department of Psychology
33 Kirkland St.
Cambridge, Ma. 02138

8. PERFORMING ORGANIZATION REPORT NUMBER
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110 Duncan Avenue, Suite B115
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13. ABSTRACT (Maximum 200 words)

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1. Developed a theory to explain perceived depth in untextured stereograms which relies on the principle of generic image sampling.
2. Conducted experiments on visual search and visual texture segregation which show that early filter outputs are not accessible to either of these two operations.
3. Discovered a new form of implicit memory which is uniquely shortlasting (approx 30 seconds) and which assists in enabling more speedy popout with repeated trials.
4. Developed a new theory of binocular vision which relies heavily on the importance identification of half-occlusions.

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AFOSR Technical Report KEN NAKAYAMA

Progress for period October 1, 1991 - September 30, 1992

Work has proceeded in a number of distinct areas:

1. In collaboration with Shinsuke Shimojo, we developed a theory to understand otherwise puzzling stereoscopic phenomena seen with untextured stereograms. The theory introduces the concept of varying vantage points that the observer can take with respect to a candidate of surfaces. Assuming random positions of an observer with such surfaces, one can compute the probability of various topological views that would be sampled. Employing the generic sampling principle, we explain why observers see surface discontinuities, subjective contours, and transparency in very simple untextured stereograms. We further suggest that the generic sampling principle emerges essentially as a by-product of associative learning, between images and surface representations. (see Nakayama and Shimojo, 1992; below).

2. In collaboration with Dr. Zijiang He, we have discovered that visual search and visual texture segregation has little or no access to primitive features. Instead, we find each of these processes has as an input, a level of surface representation or higher. (see He and Nakayama, 1992; below).

3. In collaboration with Dr. Vera Maljkovic, we have further delineated a new form of memory which is responsible for much faster response times in a "popout" task. Our work indicates that there is a rapidly decaying trace which lasts approximately 20 seconds, which linearly cumulates over time, and which can account for the difference between reaction times for blocked vs. mixed trials. This memory or priming can occur for features or position. It is not retinotopic and it is not eye specific. Furthermore, it is mainly a positive priming for the target color or position and less a negative priming for the color of the distractor or its position. Because this memory is essentially "implicit", it represents an unexplored aspect of short term memory not heretofore investigated. It is our hypothesis is that this is a working memory for motor and attentional procedures

4. In collaboration with Dr. Bart Anderson, we are writing a major paper on the nature of binocular correspondence. Based on new empirical findings which show the importance of contrast magnitude in correspondence matching, we suggest that the detection of half-occlusions (contrast energy present in one eye and not in the other) is processed as early as disparity matching information, thus re-casting the fundamental problem posed by previous stereoscopic research. We develop a new theoretical framework to account for these new findings and suggest that stereo models which employ rich primitives (a feature vector more seen at a hypercolumn level) will be much more promising than simple primitives like zero crossings or points. Our point is that the visual system must not deal with the false matching problem by eliminating candidate matches and must never make false matches in the first place, otherwise half-occlusions will not be found. In addition, with Dr. Shimojo, we are also dealing with the half-

occlusion problem, showing that unpaired points are not subject to obligatory Panum matching in unpaired zones.

5. In collaboration with Dr. Preeti Verghese we are completing a comprehensive study relating visual discriminability and visual search. By looking at three different stimulus dimensions (color, orientation, and spatial frequency), we conclude that one cannot dichotomize visual search into serial vs. parallel tasks. More importantly, one cannot easily think of the performance of visual search tasks in terms of a continuum from serial to parallel, for there are examples where distractor number continues to have a great effect, even in cases where increasing discriminability has no effect. These cannot be easily explained by limited capacity (serial models) nor parallel processing models. We are also developing new techniques to study visual search using response on demand techniques, where one can more efficiently specify points on a speed-accuracy trade-off function.

Publications which have appeared in the current year under review.

Bravo, M. and Nakayama, K. The role of attention in different visual search tasks. **Perception and Psychophysics 51**, 465-472, 1992

Nakayama, K. and Shimojo, S. Experiencing and perceiving visual surfaces. **Science 257**, 1357-1363, 1992

He, Z. J. and Nakayama, K. Surfaces vs. features in visual search. **Nature 359**, 231-233, 1992

Mackeben, M. and Nakayama, K. Express attentional shifts. **Vision Research 33,** 85-90, 1993

Manuscripts under review:

Shimojo, S. and Nakayama, K. Interocularly unpaired zones escape local matching. (submitted to Vision Research)

Manuscripts in preparation

Anderson, B. L. and Nakayama, K. Half- occlusions and binocular correspondence matching (for submission to Psychological Review)

He, Z.J. and Nakayama, K. Texture discrimination: beyond filtering (for submission to Vision Research)

He, Z.J. and Nakayama, K. Amodal completion and visual search

He, Z.J. and Nakayama, K. Within surface paths preferred in 3-D apparent motion.

Maljkovic, V. and Nakayama, K. Priming of popout: I role of features

Maljkovic, V. and Nakayama, K. Priming of popout: II role of position

Verghese, P. and Nakayama, K. Visual search: different trade-offs for discriminability, number, and time.

Plans for the future:

We plan to continue work in all of the areas described above. In most of these projects, the vast majority of the empirical and theoretical work has been done and significant effort will be devoted to writing papers.

New projects with Dr. Zijiang He and Vera Maljkovic will be undertaken. With Dr. He, we will be studying the role of surface representation in motion perception. Dr. He has found that motion tends to "stick" to surfaces and we will explore the relation of this phenomenon to "attentive tracking" as outlined by our colleague, Professor Patrick Cavanagh. With Vera Maljkovic, we will explore two new avenues: First, we will examine whether our memory system under study is indeed "implicit", using techniques from "explicit" memory research. In this area, we have consulted with Professor Dan Schacter, who is a leading authority on implicit memory. We are also (and in collaboration with Rob McPeek, a first year graduate student and Professor Alex Skavenski, on sabbatical leave from Northeastern U.) very interested in seeing whether our priming of popout task will also generalize to saccadic eye movement latencies. We have purchased a commercial eye movement system to do this research and we are close to utilizing it for experimental purposes.

Ken Nak 2-1-93